ACIDIC PRECIPITATION IN ONTARIO STUDY

SYNOPSIS

IMPACT OF SUDBURY SMELTERS ON WET AND DRY DEPOSITION OF ACIDITY AND SULFATES IN ONTARIO

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Synopsis

Impact of Sudbury Smelters on Wet and Dry Deposition of Acidity and Sulfates in Ontario

An analysis has been carried out to determine the impact of Sudbury smelters on wet and dry deposition of a number of substances, including acidity and sulfates. The analysis was primarily concerned with a comparison of air and precipitation concentrations, and deposition, at several receptor areas in Ontario, during the prolonged smelter shutdown period lasting from the second half of 1982 through the first quarter of 1983, with the corresponding values during previous years, when the smelters were operational. It involved an examination of air parcel trajectories, and detailed meteorological analysis, to identify days when Sudbury sources could have been affecting the receptor areas; statistical analysis of the data; and the use of mathematical modelling to determine the fate of the smelter emissions.

Our findings are summarized as follows:

- During the smelter shutdown period, Ontario SO_2 emissions decreased markedly (by about 60% of the provincial total for the corresponding periods in 1980/81 and 1981/82). However, on the eastern North America scale, this decrease - 0.5 million tonnes of SO_2 during 1982, for example - represents only about 2% of the eastern North America total. It should be noted that during the same period, states south of the Great Lakes experienced SO_2 emission decreases in excess of one million tonnes.

- Based on a comparison of data during the Sudbury shutdown and operating periods, as well as other types of data analyses, we conclude that, beyond the Sudbury Basin, the impact of the Sudbury smelters on wet deposition of pollutants in Ontario constitutes only a small fraction of the current total wet deposition.

- For precipitation acidity (measured by the pH), the Sudbury impact is too small to quantify by the methods currently available.

- For sulfates, deposition data combined with meteorological analyses suggest that the contribution to the total wet deposition attributable to Sudbury can be up to 15%; however, the actual percentage is difficult to quantify. Figure 1 shows estimates of upper limits of the Sudbury contribution based on meteorological analyses. Mathematical modelling results are in general agreement, giving a Sudbury contribution on the order of 10-15% in central Ontario, about 5% or less in southern Ontario, and a somewhat greater impact to the north and northeast of Sudbury. Figure 1 also includes predictions of MOE's model at some of the sites where meteorological analyses were carried out. Note that the numbers in Figure 1 (as well as Figures 2 and 3 below) represent the percentage contribution due to Sudbury on an annual basis. For purposes of reference, Figure 4 shows total wet deposition for sulfates during 1982 (from which the actual Sudbury contribution at different receptor areas in Ontario can be estimated).

- The impact of the Sudbury smelters on dry deposition of sulfur compounds (SO_2 and SO_4) is greater than for wet deposition. Trajectory analyses, detailed meteorological analyses (which give an estimate near the upper limit), and mathematical modelling all suggest that the smelters contribute on the order of 10-20% of the total sulfur dry deposition in central and northeastern Ontario, and less than 10% elsewhere. Figures 2 and 3 show the estimated contribution of Sudbury to the SO_2 and SO_4 deposition at a number of monitoring sites in Ontario, and include the results of trajectory analyses, detailed meteorological analyses (shown as "less than" values), and mathematical modelling. For purposes of reference, Figure 5 shows total sulfur dry deposition for 1982 (expressed as kilograms of sulfate, per hectare per year). Note that the dry deposition is considerably lower than the wet deposition.

Thus, we come to the following conclusions:

1. Sudbury contributes a relatively small fraction of the total atmospheric deposition of acidity and sulfates in Ontario (for sulfur, the Sudbury contribution can be up to 15% of the total for wet deposition, and 40% or less for dry deposition). Note that the smelters emit very little NO_x.

2. Most of the atmospheric deposition of acidifying substances in Ontario is due to sources to the south of Sudbury.

3. The deposition problem is related to multiple emission sources, and therefore will require widespread abatement measures to achieve target loadings. Control of the Sudbury smelters alone will result in only slight decreases in atmospheric deposition at receptors in Ontario.

Details supporting the above conclusions may be found in the attached reports:

1. D. Yap, "Emission Inventory of Ontario and Eastern North America During 1980-1983 with Emphasis on the Sudbury Shutdown Period".

2. D. Yap and J. Kurtz, "Meteorological Studies to Quantify the Effects of Sudbury Emisisons on Precipitation Quality and Air Quality During 1980-1983 with Emphasis on the Shutdown Period".

3. A.J.S. Tang, W.H. Chan and M.A. Lusis, "An Analysis of the Effects of the Sudbury Emission Sources on Wet and Dry Deposition in Ontario".

4. G. Ellenton and P.K. Misra, "Examination of Monthly Wet Sulphate Deposition by a Lagrangian Model and Its Application to Study the Effects of Source Control on Receptors"

5. M.A. Lusis, "Summary: Source Apportionment Analysis of Air and Precipitation Data to Determine the Contribution of the Sudbury Smelters to Atmospheric Deposition in Ontario".

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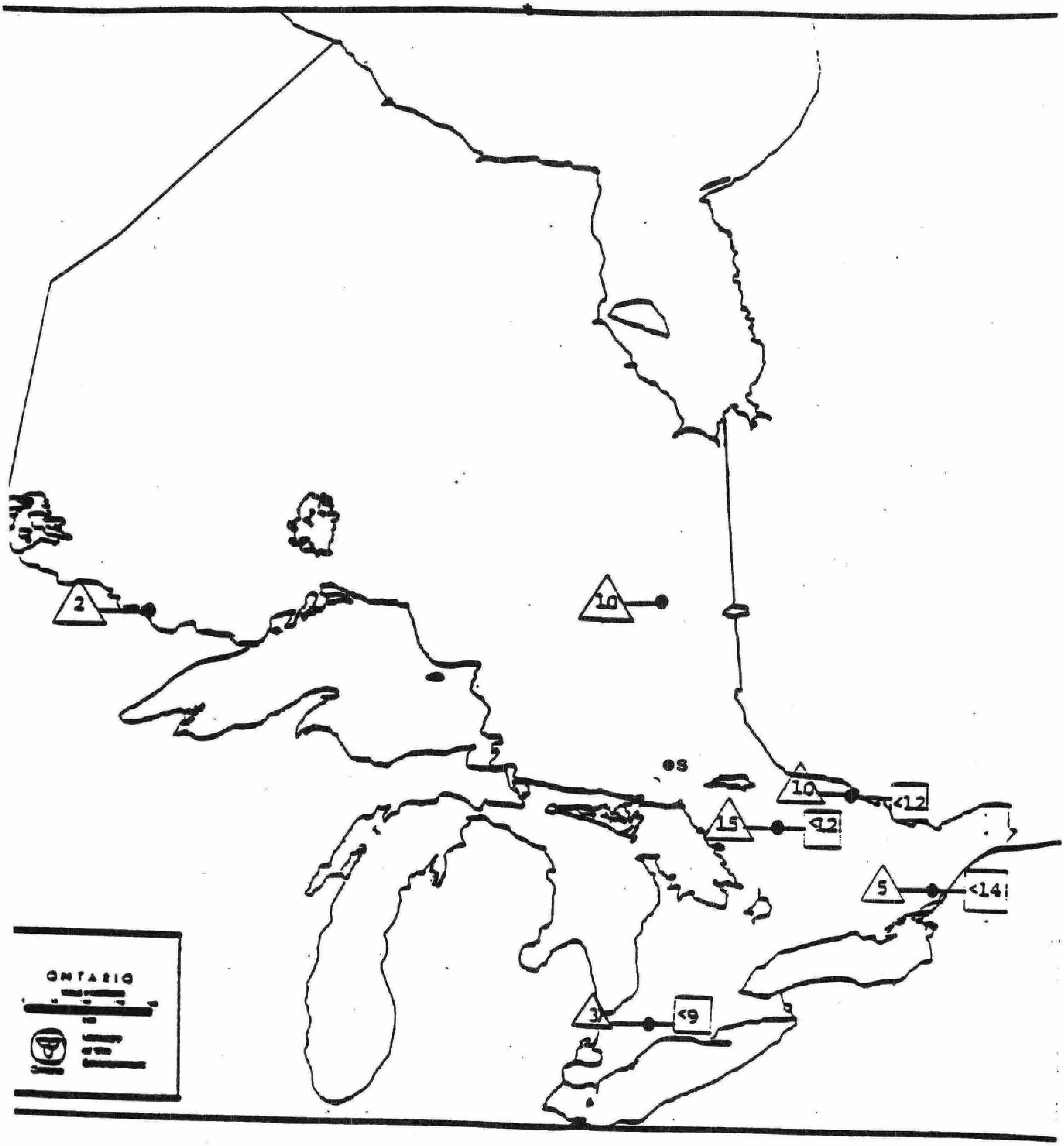
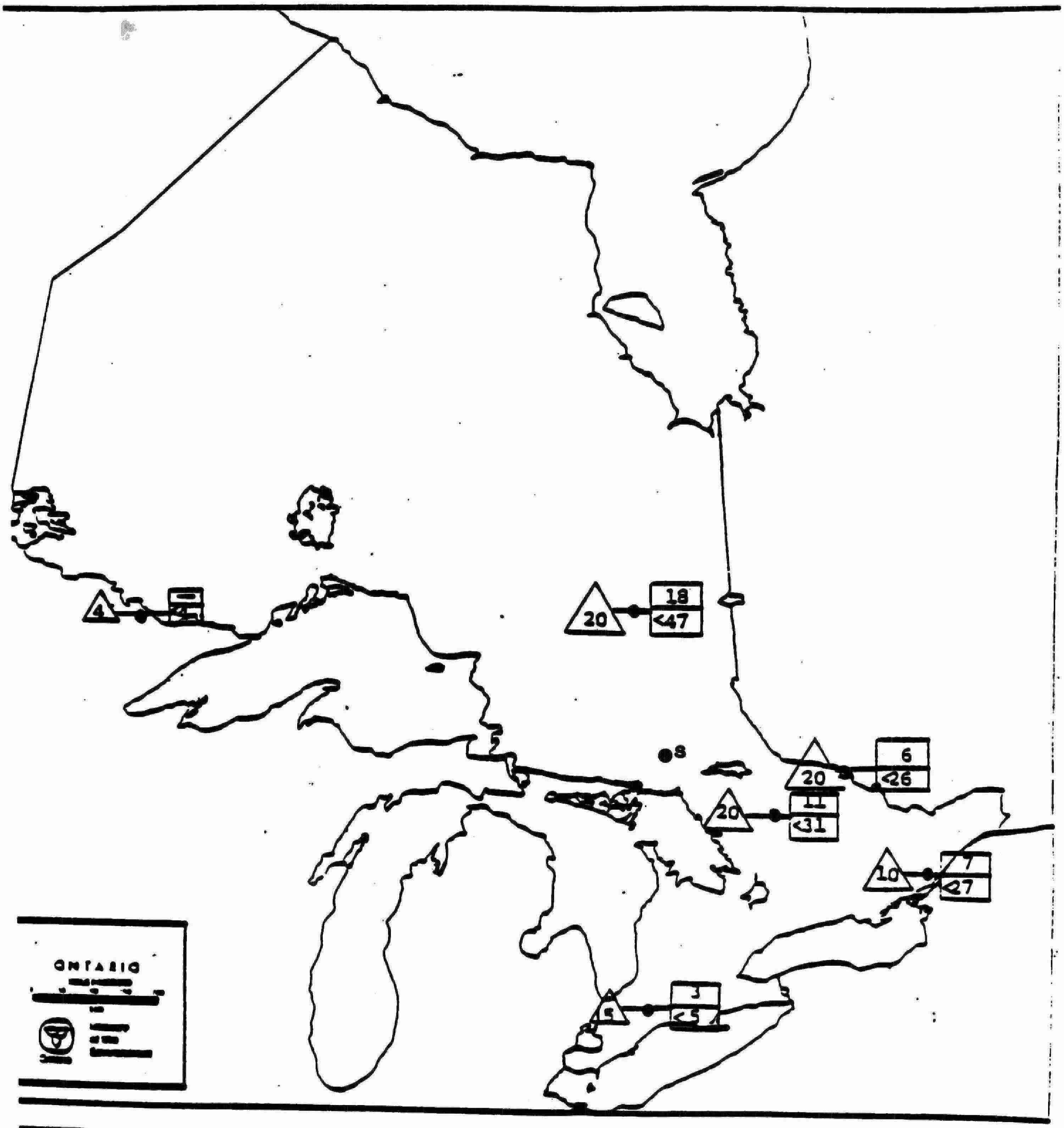
FIGURE 1: SO_4 Wet Deposition (% of annual total due to Sudbury)



- Meteorological Analysis (upper estimate)

- MOE's Lagrangian Model

FIGURE 2: SO_2 Dry Deposition (% of annual total due to Sudbury)

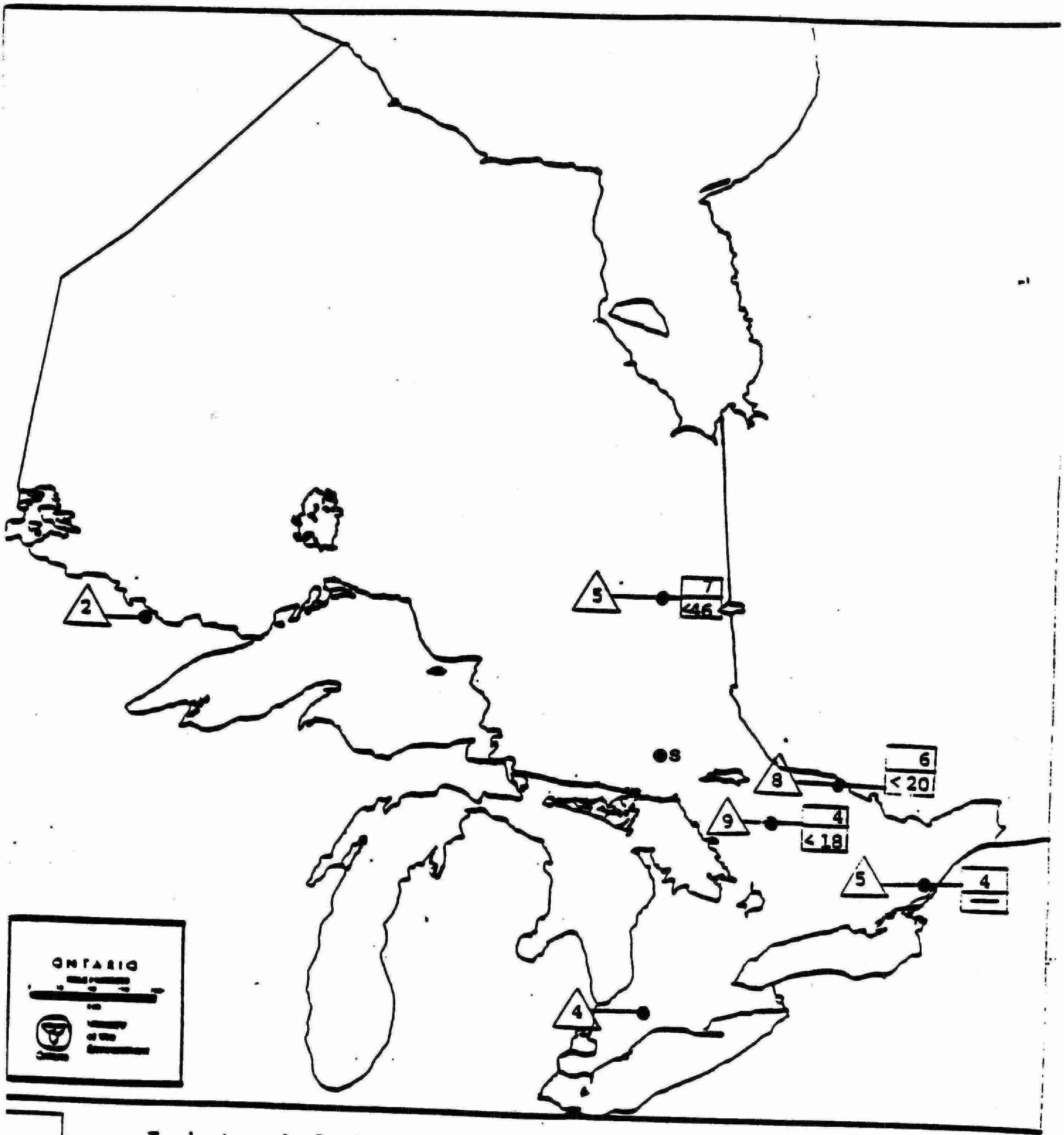


Trajectory Analysis

Upper Estimate, Detailed Meteorological Analysis

- MOE's Lagrangian Model

FIGURE 3: SO_4 Dry Deposition (% of annual total due to Sudbury)



Trajectory Analysis

Upper Estimate, Detailed Meteorological Analysis

△ - MOE's Lagrangian Model

FIGURE 4: Annual Wet Deposition (kilograms per hectare) of SO_4 for 1982

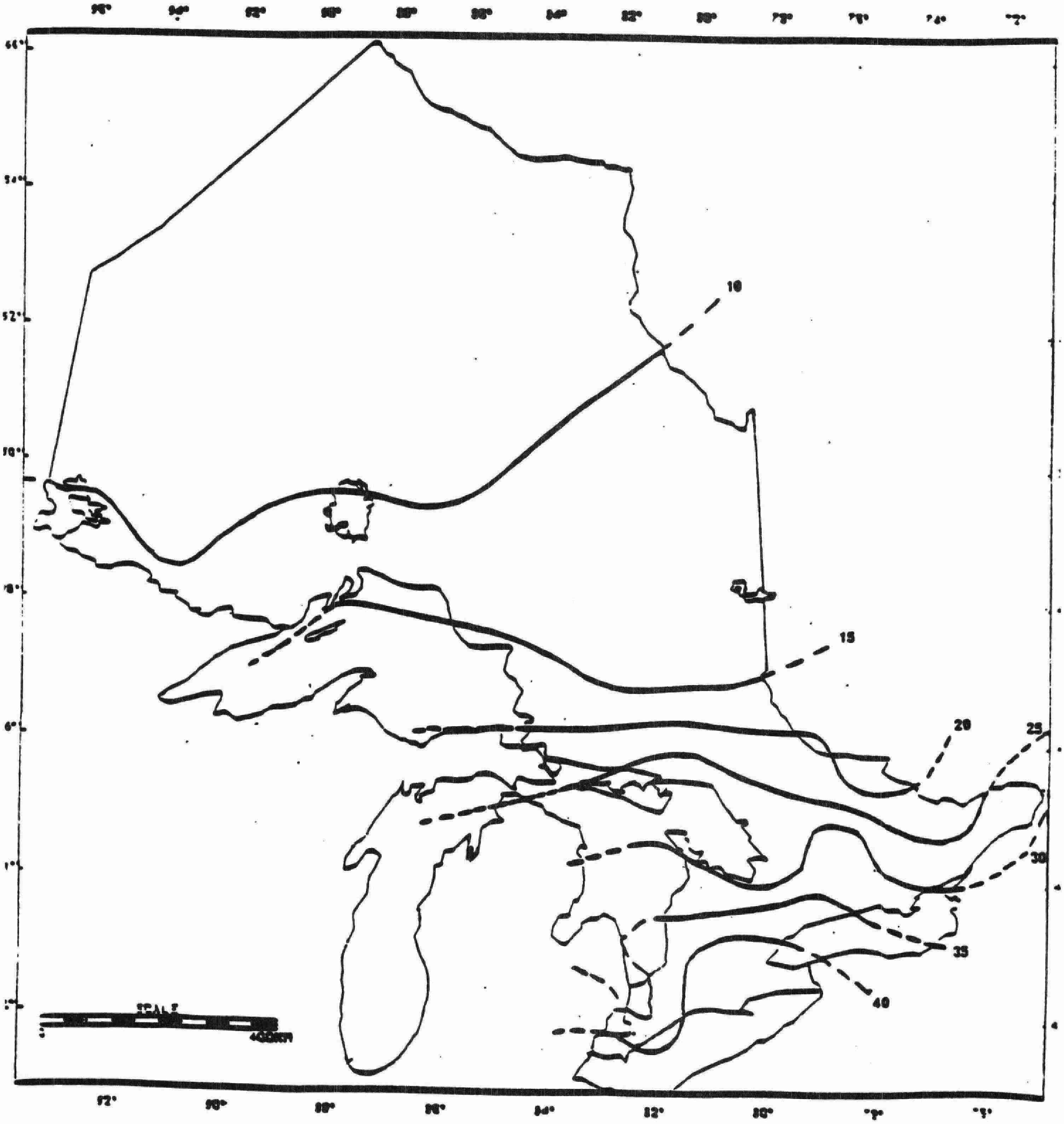


FIGURE 5: Annual Sulfur Dry Deposition (expressed as kilograms SO_4 per hectare) for 1982